Self-sustainable textile electronics require electronic and energy storage devices. Different types of fiber supercapacitors with twisted structure using a single metal, polymer wire or carbon nanotube yarns have been demonstrated, revealing several drawbacks in terms of structural stability and robustness, as well as low energy and power density. In this report, we designed a coaxial fiber supercapacitor, which consists of carbon microfibre bundles coated with multiwalled carbon nanotubes as a core electrode and carbon nanofibre paper as an outer electrode. The ratio of electrode volumes was determined by a half-cell test of each electrode. The capacitance reached 6.3 mF cm$^{-1}$ (86.8 mF cm$^{-2}$) at a core electrode diameter of 230 μm and the measured energy density was 0.7 μWh cm$^{-1}$ (9.8 μWh cm$^{-2}$) at a power density of 13.7 μW cm$^{-1}$ (189.4 μW cm$^{-2}$) which were much higher than the previous reports. The change in the cyclic voltammetry characteristics was negligible at 180° bending, with excellent cycling performance.